WIRELESS-BASED OCEAN-BOTTOM SEISMOGRAPHIC OBSERVATION SYSTEM

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Abstract- Recent seismic activity, possible induced, in the Gulf of Valencia or the intense underwater seismic activity associated with the eruption of El Hierro (2011-2012) shows the importance of controlling the seismicity located in the sea that is not covered by the terrestrial monitoring networks. To overcome this problem, this work propose the development of a "Wireless-based" Ocean-bottom Seismographic Observation System which will integrate different measurement and data communication technologies in a new design with a buoy on surface and a seafloor seismometer. The integration of real time data generated by marine seismometers will be possible thanks to the development of wireless communication systems, the increasing potential for miniaturization of sensors, storage devices and data processing, which have opened the door to a new generation of distributed intelligent sensor networks that are connected by communication networks.

Keywords— seismometer, OBS, wireless communication, time synchronization, GPS, Ethernet, IEEE-1588

I. INTRODUCTION

The study of seismic activity has played a key role in increasing the understanding of the dynamics of the Earth and its internal structure. Variations in real time seismicity provides knowledge of the state of local and regional stresses in the short and medium term, essential information to study the potential seismic risk that may affect infrastructures and population located in the area . Seismic information is obtained indirectly from the knowledge of traveling time of seismic waves and their trajectories. For this, it is important to record these waves with different azimuths using seismic sensors.

The resolution of these measurements depends on the coverage and number of sensors capable of recording these waves and their arrival times. On land, the resolution, and coverage is adequate at the regional level, and is relatively easy to be increased in specific cases using portable seismic stations (e.g. for microseismic studies). However, it is important to note that the dynamics of the lithosphere associated with the interaction of tectonic plates happens mostly in ocean basins and margins, yet the distribution of marine seismic stations is far from their equivalent in land, either because of the technological complexity related with the environment, or the difficulties to access the recorded data.

Nowadays, the most widely used instruments to study the seismic process are the underwater seafloor sensors (Ocean Bottom Seismometer OBS). The OBSs are autonomous instruments which are anchored in a fixed position on the seabed during the experiment. One of the main objectives to use the marine seismometers is to expand awareness and enhance the geometry of the terrestrial seismic network in marine margins, allowing precise localization of seismicity. Also, it provides a high-resolution structural imaging in active margins, reflecting accurately the seismicity. Moreover, the expansion of the azimuthal coverage around the epicenter, allows to determine the focal mechanisms of earthquakes, providing the purely structural images from the active seismic data with data about dynamic components and thereby identify the tectonic structures (active faults, inter-plate seismogenic zones) and understand the active deformation processes which are generating large earthquakes that periodically plague these regions.

Essentially, every marine seismometer consists of an anchor, autonomous data logging system with high accuracy clock and the sensor system composed of hydrophone and tri-axial geophone (you can see a state of the art in A. Mànuel, et al 2012). The geophone transforms the movements and/or ground vibrations of the three components (one vertical and two horizontal) into electrical signals and the hydrophone is transforming the variations of the water pressure wave. The information provided by these analog sensors in a noisy environment, allow us to estimate the magnitude of earthquakes (seismicity) and to know the characteristics of the subsoil (active seismicity).

One of the main disadvantage of the use of OBSs is that they are submerged with no possibility to communicate their data in real time and without access to GPS signal synchronization. Therefore, the OBS clock is synchronized with the GPS signal before the deployment, the data is retrieved after the OBS recovery in surface and the clock time drift is calculated also after the OBS recovery in surface using the same signal. For the signal processing, the timestamps are corrected assuming that time drift is linear throughout the experiment. Correction has a direct effect on both passive seismicity where is investigated the location and magnitude of the earthquake, and active seismicity where the goal is to obtain the final model of the speed of sound through the layers beneath the seabed.

II. SEISMOMETERS DESIGN

To overcome the disadvantages of the OBSs, some Cabled-based Ocean-bottom Seismographic Observation System have been proposed and developed to be used with multidisciplinary underwater cabled observatories like the COBS instrument [O. Pallarés 2012] installed in OBSEA observatory [Agguzi 2011]. The advantages of having a point of measurement which provides long series of data, in real time, are conditioned by the impossibility to change the location and the high cost for both installation and for maintenance (vehicles submarines, cranes, cable ship, etc.). This gives a special motivation for the development of autonomous seismometers with permanent access to data recorded using surface buoy (Figure 1).

The Wireless-based Ocean-bottom Seismographic Observation System is composed of ocean-bottom seismometers (Photo 1), umbilical cable for power and communication and surface buoy with wireless communication, and energy harvesting systems. The ocean-bottom seismometers is designed based on an autonomous OBS and adapted to Ethernet communication. The IEEE 1588 Grand Master Clock (GMC) located in the surface buoy is synchronized with GPS. The real time clock of the LM3S9B96 board is synchronization through Ethernet network with GMC using IEEE 1588 protocol [J. del Río 2011]. As shown in Figure 1, the main controller is a Stellaris Luminary LM3S9B96 with IEEE 1588 PTP hardware support. In this system, the real time clock of the LM3S9B96 board synchronized with GMC is used to timestamp the seismic data. The PPS signal from the LM3S9B96 is used with a PLL to generate the sampling frequency for the ADC converter.

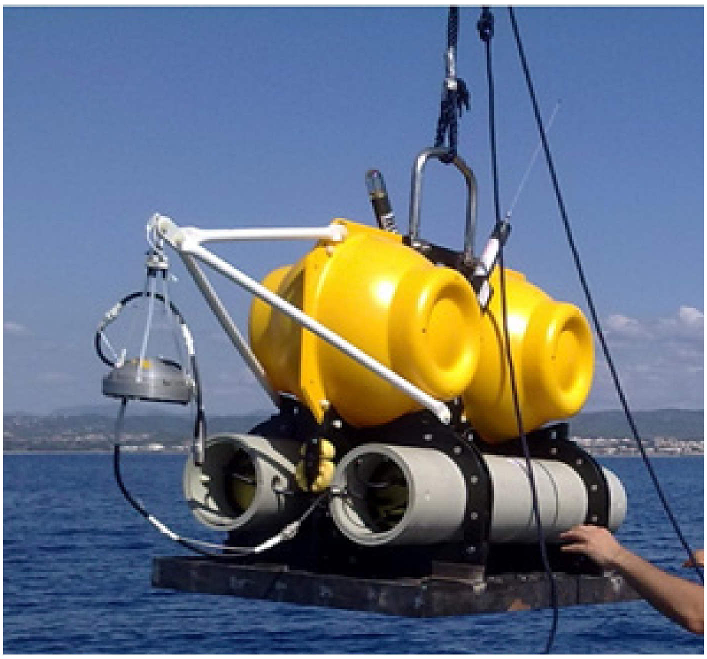

Photo 1 Ocean-bottom seismometer

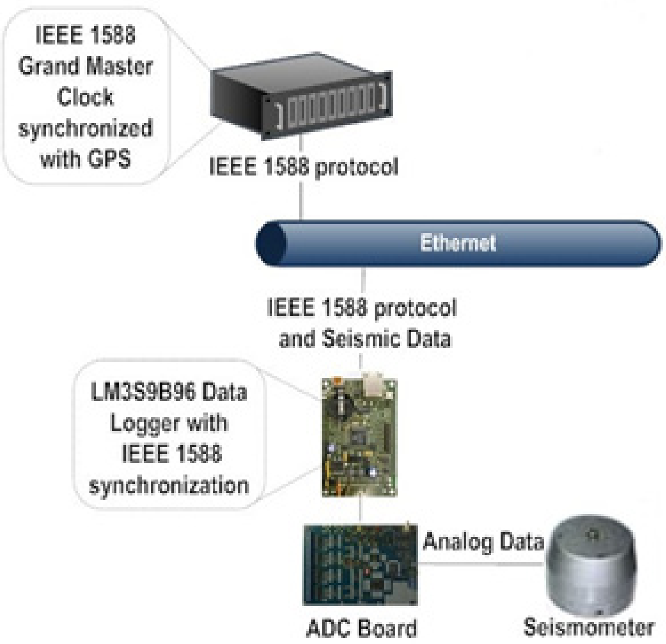

Figure 1 Luminary LM3S9B96 Broadband Seismometer with IEEE 1588 synchronization

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